The Effect of Multimarket Scope on Firms' Compatibility Choice

Chapter 2

The Effect of Multimarket Scope on Firms' Compatibility Choice

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1 Introduction

The knowledge economy exists in vertical value chains that tend to run in three levels of activity:

technology suppliers → network operators → content, service providers.

The technology providers supply information and communications technology (ICT) products such as computer hardware, connection equipment, and software. Network operators acquire these ICT products to create physical data and voice communication networks. On these networks, service providers run services (applications) to distribute information goods (content) or to enable communication between people. Products from different companies need to connect together to make these services work. Pieces of hardware and software need to interoperate. Compatibility is the condition that describes the connectivity and interoperability of these technologies, components, and products. Compatibility is an important condition for a flourishing knowledge economy.

There is much debate about what causes firms to prefer their technologies to be compatible (see Shapiro and Varian, 1999, for a topical textbook, and Katz and Shapiro, 1994, and Matutes and Regibeau, 1996, for surveys). Public sympathy tends to be with those who support compatibility and standards. There is rightly much support for the Internet custodians in the IETF (Internet Engineering Task Force) and the World Wide Web Consortium. But private companies have more to think about than public sympathy. They may come out in favour of incompatible technologies. For example, videogame consoles by Sega and Nintendo are incompatible with each other (Van Wegberg, 1996).

In the literature about compatibility choice, an important insight is that a firm's choice of (in)compatibility depends both on the absolute size of the market demand created by a new technology and the firm's share of the associated revenues (Shapiro and Varian, 1999, p. 198). An incompatible technology, based on a proprietary standard, may increase or safeguard the firm's appropriation of revenues. Incompatibility may be the price to pay if suppliers want to appropriate revenues from their technology development efforts. Compatible technologies, on the other hand, protect users' investments in these technologies. They may increase the absolute size of market demand. An innovator may decide to give up control over its technology in order to trade-off its share of total revenues for the total size of revenues.

The basic argument in this chapter is that we need to understand a firm's compatibility choice in the broad context in which it operates. That is, we need to look beyond the direct effects of compatibility choice for the market place. Firms tend to be active in multiple markets. Their compatibility choice for a technology may have direct effects in one market, that have indirect consequences in its other markets. As a result, the choice of compatibility may work out differently for a pure player, a firm that is active only in the one product market that is directly concerned, than for multimarket firms with interests in related markets. A pure player needs to recoup its technology efforts in the market directly affected, so it tends to focus on the appropriability of its investments (the appropriability motive). A multimarket firm can afford to focus on growing the market, knowing that it can recoup its investments in other markets that are positively affected by the growing market (the market demand size motive). When the market directly affected by a standard has spillovers on other markets, the market demand size motive when choosing a standards' regime may be more important than the appropriation motive.

We first discuss the problem at hand. Then we discuss a simple model that highlights the compatibility choice in a context with multiple markets, multimarket firms, and cooperation. A brief example of mobile Internet economics illustrates the issues in a real world context. The appraisal points to future research issues that our model opens up.

2 Product Portfolio, Compatibility Choice, and Standardization

›atibility is a technical feature of the relationship between two or more ›nents in a system. There are various forms of compatibility (Farrell aloner, 1986; Katz and Shapiro, 1986; Matutes and Regibeau, 1996). ›mmon feature of compatible products is that they enable their users to share resources. Efficiency tends to be the underlying motive for developing compatible technologies and products. If a product enables communication, such as a telephone, different products are called compatible if their users can communicate with each other. All users who use different, but compatible, products together form a network. This is a direct network externality (Katz and Shapiro, 1985 and 1986).

Another form of compatibility occurs when individual products are components that need to be combined to be of use to the user. Potentially complementary components need to be compatible for the user to be able to actually combine them in a system (Matutes and Regibeau, 1988). Complementary systems can also lead to an indirect network externality, that is, sales of either compatible product benefit users of the other compatible product indirectly, by stimulating sales, investments, and improvements of the complementary product. Another indirect externality occurs if interchangeability of parts facilitates mass production when that leads to economies of scale. In short, if products are compatible, they enable a positive network externality to their users.

The choice to make products (in)compatible has important effects on the demand side of the market. Suppliers may agree with each other up-front to make their products compatible. Compatibility is likely to benefit the users (all else remaining equal) by enabling positive network externalities. It increases the network users can communicate with (the direct network externality), it increases the scale at which components are built, or it enables the provision of more, better or cheaper complementary products, like hardware and software (indirect network externalities).

A firm may also, however, prefer that its product is incompatible with those of a rival. It may be costly to achieve compatibility, as this may require R&D investments, or building an adapter (Katz and Shapiro, 1985). If their products are incompatible, each firm will try to generate the network externalities mentioned above (such as economies of scale) by fierce competition. Firms are more willing to compete for customers today, if they believe that these customers form a network (an installed base) that increases the utility of their product for future customers. The associated price cutting may make this scenario more attractive to users than the case when firms agree *ex ante* on compatible products (Katz and Shapiro, 1986). Incompatibility may also stimulate firms to do R&D, when each needs to build up an installed base of users. Their greater incentive to do R&D may be socially beneficial (Farrell and Katz, 1998), except when the firms overinvest in R&D (Kristiansen, 1998). Once the products are introduced in the market, their compatibility may facilitate customer switching between their product and their rivals' products, thus increasing competition *ex post*.

Suppliers may prefer their products to be compatible, in order to slow down an R&D race, and to avoid wasteful duplication of R&D effort. Compatibility may also prevent a crippling price war *ex ante* (before a standard is established) to built up market share.

In an evolutionary context, Metcalfe and Miles (1994) distinguish between short term and long term effects of compatibility. The short-term effect of standardization is to create order and reduce variety. It reduces variety for producers (fewer technologies to choose from) or consumers (by eliminating products that do not use the technology that got standardized). Standardization also, however, expands the market, which itself tends to arouse creativity and variation. Demand growth and large market size stimulate the development of compatible and complementary products.

There are various ways to achieve compatibility. One way is to formulate a standard, a set of specifications, such that products that satisfy these specifications, are compatible. Another is to build an adapter (an interface, converter or a gateway) that couples different products to integrate their networks (e.g., Choi, 1996a). Creating an adapter makes two products partially compatible, which shows that the compatibility choice does not have to be an all or nothing affair (De Palma, Leruth and Regibeau, 1999). The choice of compatibility can be unilateral, if one firm decides to build an adapter, or bilateral, if all suppliers have to agree on a standard (Matutes and Regibeau, 1988). In this chapter we focus on the latter route, the definition of a standard.

Firms can follow several paths in establishing a standard. Each contender may develop the technology, and then introduce a product in the market. Competition in the market for customers may settle the standard. The technology developers may license their technology to rival producers, in order to increase the bandwagon behind their technology. In this case, competition for rival suppliers' adoption decisions may settle the standard. Firms may cooperate to develop a technology together. Competition then takes the form of a battle between alliances. Finally, all relevant firms may cooperate up-front to develop and adopt a technology. If there is a standard setting organization, firms may develop a technology and submit it to the organization. The latter will take charge for a certification, adoption, diffusion, and user feedback process

In these scenarios, cooperation increases from the licensing strategy up to the institutionalized standard setting process. Firms face a trade-off between a larger chance of adoption (by cooperation) and a loss of control and appropriation (if cooperation implies a loss of revenue or control to the partners). Technology developers can choose which mode of standardization to adopt. They will try to anticipate which mode best serves their interests. In this chapter we focus on the first and third standardization mode in Table 2.1: go it alone or cooperate to develop the industry-wide technology standard.

Table 2.1 Modes of standardization

	Cooperation	Appropriation	Control	Who chooses standard?
Develop technology and launch product	None	Via market sales	Total	Users
Develop and license technology	Individual development Joint adoption	Via market sales and licensing revenues	Via licensing contracts	Users and suppliers
Alliance to develop and adopt technology	Joint development and adoption	Share licensing revenues, and product sales	Negotiation	Suppliers (and users if rival alliances exist)
Submit technology to standardization institute	Joint development; adoption stimulated by institute	Share in licensing revenues (if collected), and market sales	Participation in process	Standardization institute, its members (users, if members, or if rival technologies hit the market)

A proprietary standard offers control and revenues to the firm. This offers incentives for the firm to invest in its technology. If firms develop competing technologies, they may experiment and choose different avenues of technological development (Choi, 1996b). A cooperative standardization process reduces the scope of this experimentation, and may thus lead to a loss of revenue.

A collective process may slow down innovation, relative to independent actions by the competing firms. Farrel and Saloner (1988) show that bargaining in a collective process delays adoption of a standard, compared with the case of uncoordinated choice of technology. However, having one agreed upon standard can also speed up diffusion and adoption by users, as these need not fear that they buy the wrong standard. Users may postpone or avoid adoption, if they anticipate that they may end up with the standard that loses out later, thus forcing upon them the costly switch to the standard.

Cooperation may take the form of an industry-wide alliance or of competing alliances. In the latter case, the product market (both suppliers and buyers) still face a choice between competing (incompatible) technologies. Axelrod, Mitchell, Thomas, Bennett and Bruderer (1995) explore competing alliances, when firms can choose between two competing standard setting alliances. Firms face a quandary: they will tend to avoid an alliance that contains close rivals, but they will also prefer the largest alliance (in terms of the combined market share of its members). In the real world case of competing Unix versions, they succeed largely in predicting which firms will join a particular Unix alliance.

Table 2.2 summarizes the factors that affect the choice of compatibility. New inputs in this debate may come from looking at the wider context in which firms choose compatibility of their products.

The standardization strategy and compatibility choice tend to be part of a larger environment. Firstly, an individual standard is often part of an architecture of complementary standards that together define a system, a family of products and technologies that provide services to users (Henderson and Clark, 1990). This systemic approach connects standardization policy to the overall architectures and the associated competitive environments. Secondly, the product market concerned interacts with each firm's overall portfolio of activities. A firm may be active in markets indirectly affected by the standard. The markets can be linked on the demand side or on the supply side. Thirdly, firms increasingly form clusters or networks. An individual standard can form a small part of the activities that go on in the network. The network context may well determine the choices individual firms make concerning a compatibility choice. We believe that much future research on standardization will focus on this wider, systemic/multimarket/cluster environment.

A firm's multimarket scope may reflect linkages among its product markets. A demand side link exists when, for example, the products are complementary (see Matutes and Regibeau, 1989; and Church and Gandal, 1996). A supply side link exists when, for example, there is an economy of scale or learning by doing effect in an input that the production processes for both markets share. This will lead to an economy of scope (Teece, 1980; Baumol, Panzar and Willig, 1982; Van Witteloostuijn and Van Wegberg, 1992). A shared brand name or reputation can lead to an (informational) economy of scope. It is also possible that one market's product is an input in either the production process or consumption process in the other market. The positions of these products

Table 2.2 Factors that have an effect pro or contra (+ or –) compatibility choice

Factor	Effect on compatibility choice	Literature
Resource sharing (direct or indirect network externality; complementarity)	+	Fundamental argument for standardization
R&D costs of compatibility	–	Katz and Shapiro (1985)
R&D competition if products are incompatible	– (suppliers)/ + (customers)	Farrell and Katz (1998); Kristiansen (1998)
Price cutting to sell incompatible products	+	Katz and Shapiro (1986)
An adapter can create costly, partial compatibility	+	Choi (1996a)
Competition between incompatible technologies supports experimentation	–	Choi (1996b)
Time consuming negotiations may be needed to develop a standard	–	Farrell and Saloner (1988)
To avoid direct rivals, firms may create competing alliances	–	Axelrod et al. (1995)
A high customer preference for product variety benefits from standardization of technology and components	+	Metcalfe and Miles (1994)

in the value chains of suppliers and customers will determine the potential for synergies among the markets.

This chapter explores the effect of the firm's multimarket scope on the compatibility choice. If at least one firm prefers incompatibility, competition in the market place will decide about the market shares of these technologies. We will focus on the long-term effects, rather than on the diffusion process. The outcome of this game depends on many factors, including the following:

- which competitive position and market share do the two firms have in the market concerned?
- which outside interests do the two technology developing firms have?

We will call an outside interest *weakly synergetic*, if the firm's other interests benefit from or correlate with market demand size in the focus market. The link is weak, in that we do not assume tight links between those markets, such as shared technology, compatibility, etc. If a multimarket firm is active in weakly synergetic markets, its overall performance tends to correlate with the demand size of the focus market, rather than its share in that market. We suggest the following propositions:

- *proposition (1a)*: a multimarket firm active in weakly synergetic markets tends to prefer a collectively agreed standard (the market size motive);
- *proposition (1b)*: if the firm is active only in the focus market, it will choose the standardization strategy that maximizes its value within that market (the appropriation motive). It will tend to prefer incompatible technologies.

A Model

Two firms seek their preferences for the compatibility of their products. The question is: does a firm for whom the product is part of a wider product line address the standardization issue differently than a pure player?

Say, two firms develop a new product technology. The new product (product A) has a positive network externality on the demand side. The utility of the product A to each user increases in the number of users of compatible technologies. Users may prefer a single compatible technology. The suppliers may not be so sure. They may cooperate to develop a single technology. If they do not cooperate, each develops its own technology. Either way, they subsequently compete in the product market. Depending on the anticipated technology development costs, competition, and product demand, firms will prefer cooperation or going it alone.

The outcome may change if one firm is a multimarket firm that also supplies a weakly synergetic market B. This supplier may be more interested in the total number of users of product A than in its own market share. This may change his preferences for compatibility.

Assumptions There are two markets, market A and market B. In market A, there are two suppliers, firms 1 and 2, with their product A_1 and A_2. A buyer (j) derives a net utility from product A_i of

$$U_j = \alpha_j v_i + \beta N_i - p_i, \tag{1}$$

where v_i indicates the quality of the product and N_i the size of the network (i.e., the demand). If the products are compatible, both products have the same network (called N_A), otherwise each product has its own network (N_i). The consumer chooses the product that gives the largest net consumer surplus. If the net consumer surplus is negative, she does not buy at all. The α_j are uniformly distributed over an interval $[\alpha^{min}, \alpha^{max}]$ with a density of γ, which implies that there are $N = \gamma(\alpha^{min} - \alpha^{max})$ potential buyers.

We assume that firms compete in prices p_i (Bertrand competition). Each maximizes gross profits, given the investments made to develop the technology. Marginal costs are given and identical for both firms at c. The quality levels are given, and different. We assume that firm 1 has the high quality product: $v_1 > v_2$. We assume, therefore, that quality differences are unrelated to marginal costs. An example where this tends to hold are information goods.

Market B is of a complementary good to market A. Product B, that is, has a higher utility to customers who also use product A than for those who did not buy A. It does not matter here whether a customer bought A_1 or A_2, nor does it matter whether A_1 and A_2 are compatible. We should not think of A and B as compatible products, therefore, like computer hardware and software. See Church and Gandal (1996) for that. Instead, think of market A as computers and market B as for media with information about computers. People who have a computer probably derive more utility from reading about this market.

Only buyers in market A are willing to buy product B. For convenience, we assume market B is a monopoly, and the inverse market demand function is: $p_B = a - \frac{b}{N_A} q_B$ where N_A is the number of buyers of product A. In market B, these buyers are homogeneous (that is, each has his own demand curve for product B: $p_B = a - bq_B$). The monopolist's marginal production costs are zero, for convenience. Product B will always be supplied, therefore, and the market outcomes are: $q_B = \frac{a}{2b} N_A$; $p_B = a/2$; $\pi_B = \frac{a^2}{4b} N_A$; $CS_B = \frac{a^2}{8b} N_A$, where CS is the total consumer surplus. The consumer surplus per individual buyer, CS_j, is $\frac{a^2}{8b}$. If we define $d = \frac{a^2}{8b}$, we can restate that

$$\pi_B = 2dN_A,\ CS_j = d, \text{ and } CS = dN_A. \tag{2}$$

For convenience, we assume that consumers are myopic, that is, if they decide about buying product A they do not anticipate on the consumer surplus they realize later if they buy product B. This helps to focus on how expectations by suppliers in market A of sales in market B affect their decision making in market A.

Before firms 1 and 2 can supply a product in market A, they need to develop one first. We will assume that there are given fixed costs for developing a new product technology: F for firms 1 and 2, if their products are incompatible, and G if the two cooperate for compatible products (with F <= G <= 2F). If compatibility is an afterthought, the fixed costs G will equal 2F, as each firm develops its own technology. If compatibility has to be designed into the products from the ground up, compatible products demand joint development, and G will realize some economy of scale: G < 2F. For convenience, we abstract from characteristics of research and development such as being endogenous, uncertain, and subject to spillovers (imitation).

With these basic assumptions we have the simplest possible model that can explore mechanisms discussed in this chapter. More complex models might attempt to be more descriptively realistic.

Case 1: cooperate or not in developing a network product In this case, the suppliers in market A (firms 1 and 2) are independent from the supplier (firm 3) in market B. Market A opens up before market B, which means that both suppliers and customers first decide about buying and selling in market A, before they decide about market B.

Case 1A: compatible products If the firms in market A cooperate to develop compatible goods, they develop a single network, which means that consumer surplus is $U_j = \alpha_j v_i + \beta N_A - p_i$ where N_A is the total number of buyers. Among the consumers with increasing α's from α^{min} to α^{max}, there are two critical consumers: the consumer with the quality preference α'' who is indifferent between buying product 2 (the low quality product) and not buying, and the consumer with α' who is indifferent between products 1 and 2. The sales and network levels of products 1 and 2, and total demand, are:

$$N_1 = \gamma\,[\alpha^{\max} - \alpha'],\ N_2 = \gamma\,[\alpha' - \alpha''],\ \text{and}\ N_A = \gamma\,[\alpha^{\max} - \alpha''] \tag{3}$$

The consumer who is indifferent between product 2 and not buying has a consumer surplus of zero:

$$\alpha'' v_2 + \beta N_A - p_2 = 0,\ \text{with}\ N_A = \gamma\,[\alpha^{\max} - \alpha'']. \tag{4}$$

We assume that this marginal consumer exists, at least for a price p_2 equal to the marginal cost c:

Assumption: $\alpha^{\min} < \dfrac{c - \beta\gamma\alpha^{\max}}{v_2 - \beta\gamma} < \alpha^{\max}$, $0 < v_2 - \beta\gamma$ and $0 < \beta\gamma\alpha^{\max}$.

Remember that consumers do not anticipate on their consumer surplus in market B. The consumer who is indifferent between products 1 and 2 faces the following equality:

$$\alpha' v_1 + \beta N_A - p_1 = \alpha' v_2 + \beta N_A - p_2. \tag{5}$$

Solve these three equations in α', α'', and N_A, to get:

$$\alpha'' = \frac{p_2 - \beta\gamma\alpha^{\max}}{v_2 - \beta\gamma}$$

$$\alpha' = \frac{p_1 - p_2}{v_1 - v_2} \tag{6}$$

$$N_A(p_1, p_2) = \gamma\,\frac{\alpha^{\max} v_2 - p_2}{v_2 - \beta\gamma}$$

This gives the following demand levels, which we express as functions of the prices:

$$N_1(p_1, p_2) = \gamma\,[\alpha^{\max} - \frac{p_1 - p_2}{v_1 - v_2}],\ \text{and}$$

$$N_2(p_1, p_2) = \gamma\,[\frac{p_1 - p_2}{v_1 - v_2} - \frac{p_2 - \beta\gamma\alpha^{\max}}{v_2 - \beta\gamma}]. \tag{7}$$

The firms have gross profits $\pi_i(p_1, p_2) = (p_i - c)N_i$:

$$\pi_1(p_1, p_2) = (p_1 - c)\,\gamma\,[\alpha^{\max} - \frac{p_1 - p_2}{\nu_1 - \nu_2}],$$

$$\pi_2(p_1, p_2) = (p_2 - c)\,\gamma\,[\frac{p_1 - p_2}{\nu_1 - \nu_2} - \frac{p_2 - \beta\gamma\alpha^{\max}}{\nu_2 - \beta\gamma}]. \tag{8}$$

This is gross of the development costs of the new product (G). Each firm chooses its price to optimize its profits, given the price of its rival. The first order conditions for optimality of profits then define the reaction curves:

$$p_1(p_2) = {}^1/_2\,(p_2 + c + \alpha^{\max}(\nu_1 - \nu_2))$$

$$p_1(p_2) = {}^1/_2\,\frac{c\nu_1 + p_1\nu_2 - c\beta\gamma - p_1\beta\gamma + (\nu_1 - \nu_2)\alpha^{\max}\beta\gamma}{\nu_1 - \beta\gamma} \tag{9}$$

The second order conditions for optimality hold if $\beta\gamma < \nu_2 < \nu_1$. Equations (9) determine the equilibrium prices as:

$$p_1 = \frac{-(3c\nu_1 - 2\nu_1{}^2\alpha^{\max} + 3c\beta\gamma + \alpha^{\max}\beta\gamma(\nu_1 - \nu_2))}{4\nu_1 - \nu_2 - 3\beta\gamma}$$

$$p_2 = \frac{-(2c\nu_1 - c\nu_2 - \nu_1\nu_2{}^2\alpha^{\max} + 3c\beta\gamma - \alpha^{\max}\beta\gamma(\nu_1 - \nu_2))}{4\nu_1 - \nu_2 - 3\beta\gamma} \tag{10}$$

Substitute these to get sales:

$$N_1(p_1, p_2) = \gamma\,\frac{2\nu_1\alpha^{\max} - c - \alpha^{\max}\beta\gamma}{4\nu_1 - \nu_2 - 3\beta\gamma}$$

$$N_1(p_1, p_2) = \gamma\,\frac{(\nu_1 - \beta\gamma)(\alpha^{\max}(\nu_2 + \beta\gamma) - 2c)}{(\nu_2 - \beta\gamma)(4\nu_1 - \nu_2 - 3\beta\gamma)} \tag{11}$$

$$N_A(p_1, p_2) = \gamma\,\frac{c(3\beta\gamma - 2\nu_1 - \nu_2) + \alpha^{\max}(3\nu_1\nu_2 - \nu_1\beta\gamma - 2\nu_2\beta\gamma)}{(\nu_2 - \beta\gamma)(4\nu_1 - \nu_2 - 3\beta\gamma)}$$

The equilibrium prices also define profits:

$$\pi_1(p_1, p_2) = (v_1 - v_2)\frac{(2v_1\alpha^{\max} - c - \alpha^{\max}\beta\gamma)^2}{(4v_1 - v_2 - 3\beta\gamma)^2}$$
$$\pi_2(p_1, p_2) = (v_1 - v_2)\gamma\frac{(v_1 - \beta\gamma)(\alpha^{\max}(v_2 + \beta\gamma) - 2c)^2}{(v_2 - \beta\gamma)(4v_1 - v_2 - 3\beta\gamma)^2} \qquad (12)$$

Case 1B: incompatible products Each firm now has its own network, which means that consumer utility of product i for consumer j is $U_j = \alpha_j v_i + \beta N_i - p_i$. This modifies the characteristics of the indifferent consumers. The consumer who is indifferent between product 2 and not buying has a net consumer surplus of zero:

$$\alpha''v_2 + \beta N_2 - p_2 = 0, \text{ where } N_2 = \gamma[\alpha' - \alpha''] \text{ (from equation 3).} \qquad (13)$$

The consumer who is indifferent between products 1 and 2 has identical net consumer surplus from both goods:

$$\alpha' v_1 + \beta N_1 - p_1 = \alpha' v_2 + \beta N_2 - p_2, \text{ where } N_1 = \gamma[\alpha^{\max} - \alpha'] \qquad (14)$$
(from equation 3).

These four expressions in four variables (α', α'', N_1, N_2) give solutions:

$$\alpha' = \frac{-p_1v_2 + p_2v_2 + p_1\beta\gamma + v_2\alpha^{\max}\beta\gamma - \alpha^{\max}\beta^2\gamma^2}{Numa}$$

$$\alpha'' = \frac{p_2v_1 - p_2v_2 - p_1\beta\gamma - p_2\beta\gamma + \alpha^{\max}\beta^2\gamma^2}{Numa}$$

$$N_1 = -\frac{p_1v_2\gamma - p_2v_2\gamma - v_1v_2\alpha^{\max}\gamma + v_2{}^2\alpha^{\max}\gamma - p_1\beta\gamma^2 + v_1\alpha^{\max}\beta\gamma^2}{Numa} \qquad (15)$$

$$N_2 = -\frac{p_2v_1\gamma - p_1v_2\gamma - p_2\beta\gamma^2 + v_2\alpha^{\max}\beta\gamma^2}{Numa}$$

where $Numa = v_1v_2 - v_2{}^2 - v_1\beta\gamma - v_2\beta\gamma + \beta^2\gamma^2$.

As a result, we now have the demand levels written as functions of the prices. Anticipating consumers' demand levels, the firms choose their price levels to maximize their gross profits. Given the profit functions, which as before are $\pi_i(p_1, p_2) = (p_i - c)N_i$, for $i = 1$ and 2, we can derive the first order conditions of optimality. Reformulated, these conditions are the reaction curves of the prices. Together, they determine the prices that will prevail:

$$p_1 = \frac{c(3\nu_2 - 2\beta\gamma)(\nu_1 - \beta\gamma) + \alpha^{\max}(\nu_2^2\beta\gamma + 2\nu_1^2(\nu_2 - \beta\gamma) - 2\nu_1(\nu_2^2 + \nu_2\beta\gamma - \beta^2\gamma^2))}{Nump},$$

$$p_1 = \frac{c(2\nu_1 + \nu_2 - 2\beta\gamma)(\nu_2 - \beta\gamma) + \nu_2\alpha^{\max}(\nu_1\nu_2 - \nu_2^2\nu_1\beta\gamma) - 2\nu_2\beta\gamma + 2\beta^2\gamma^2)}{Nump}, \tag{16}$$

where $Nump = 4\nu_1\nu_2 - \nu_2^2 - 4\nu_1\beta\gamma - 4\nu_2\beta\gamma + 4\beta^2\gamma^2$.

The second order conditions for optimality imply that $\beta\gamma < \nu_2 < \nu_1$ (as in the previous case 1A) and that 0 < Numa. It will not come as a surprise that these prices lead to tedious expressions for the profit levels:

$$\pi_1(p_1, p_2) = \frac{(\gamma(\nu_2 - \beta\gamma)(c(-\nu_1\nu_2 + \nu_2^2 + 2\nu_1\beta\gamma + \nu_2\beta\gamma - 2\beta^2\gamma^2) + \alpha^{\max}(\nu_2^2\beta\gamma + 2\nu_1^2(\nu_2 - \beta\gamma) - 2\nu_1(\nu_2^2 + \nu_2\beta\gamma - \beta^2\gamma^2)))}{-Nump*Numa}$$

$$\pi_2(p_1, p_2) = \frac{(\gamma(\nu_1 - \beta\gamma)(\nu_2\alpha^{\max}(-\nu_1\nu_2 + \nu_2^2 + \nu_1\beta\gamma + 2\nu_2\beta\gamma - 2\beta^2\gamma^2) + c(-2\nu_2^2 - \nu_2\beta\gamma + 2\beta^2\gamma^2 + 2\nu_1(\nu_2 - \beta^2\gamma^2)))^2}{-Nump*Numa} \tag{17}$$

Comparing the outcomes of case 1 Firms compare their profits in case 1A, where products are compatible, to case 1B, where they are not. In order to be able to focus on the interaction with the other market B, we want to avoid complicated bargaining procedures. We will simply state that firms prefer the outcome that offers the largest total profits. This assumption implies that firms are able to exchange side payments, that is, when going from compatible to incompatible products, if one firm would gain and the other lose, the one that gains compensates the one that loses. How will they pay the side payment? Well, in the case that their products are compatible, they form an alliance to develop their technology in the first place. They may not share the development costs on a 50-50 basis. Instead, they may share costs such that if they achieve compatibility, the one that gains will compensate the loser.

In view of this discussion, we will call the difference between total profits when products are compatible and when they are not, the *compatibility bonus* to the firms:

$$Bonus_{case1} = [\pi_1(p_1, p_2) + \pi_2(p_1, p_2)_{case1A} - [\pi_1(p_1, p_2) + \pi_2(p_1, p_2)_{case1B}. \quad (18)$$

A similar expression holds for total sales. An analytical solution from comparing the total profit levels in these two cases would be hard to interpret. A solid, and obvious, analytical result is when $\beta = 0$ when there is no network effect (see the utility function (1)): the profits and sales when products are compatible equal those when they are not; the compatibility bonus is zero.

We therefore turn to a numerical solution. We assume that $\alpha^{\min} = 0$, $\alpha^{\max} = 1.5$, $c = 0.3$, and $v_2 = 0.5$. For values of β in the interval [0.01, 0.05] and v_1 in the interval [1.3, 2], the second order conditions for optimality and the other assumptions hold. The compatibility bonus is negative, so for these parameter values, the firms will prefer products to be incompatible. The sales bonus is positive: compatibility increases sales but reduces profits. Compatibility enhances the quality of products with the same network benefit. This makes the products better substitutes for each other. The result is more competition, lower prices, and higher sales as well as lower profits. Compatibility also has a direct effect on sales: by increasing the relevant network of each product (from its own sales to total industry sales), it increases the utility of the products, and thus increases sales.

Case 2: standardization when one supplier sells a complementary product
We now consider the case where the low-quality firm in market A, firm 2, has merged or acquired firm 3 in market B. This may change the preferences for compatibility of their products in market A.

Case 2A: compatible products The situation is similar to the case 1A up to the profit functions in equations (8). Firm 2 includes in its overall profits its profits in market B ($2N_A d$):

$$\pi_2(p_1, p_2) = (p_2 - c)\gamma[\frac{p_1 - p_2}{v_1 - v_2} - \frac{p_2 - \beta\gamma\alpha^{\max}}{v_2 - \beta\gamma}] + 2d\gamma\frac{\alpha^{\max} v_2 - p_2}{v_2 - \beta\gamma}. \quad (19)$$

This reflects the fact that for each customer in market A, firm 2 earns an additional profit of 2d in market B. There are N_A customers in market B, where

N_A is as in equation (6). Computations are similar to case 1A. For incompatible products, case 2B, results are derived similarly to case 1B.

We simulate numerically, to get some grip on these cumbersome formulae. We take a value of d = 0.2. We again see that sales in case A exceed those in case B: compatibility increases sales. This time, in contrast with the previous case, the profit compatibility bonus is positive: compatibility increases profits. The reason is, of course, that compatibility, as it increases sales, increases the profits made in market B, which the firms now factor into the compatibility decision of firms 1 and 2.

Results of looking at markets A and B together We are interested in the effect of market B on the relative profitability of compatible products. That is, do activities in weakly synergetic markets tend to increase the compatibility bonus?

For the parameter values simulated, the two firms will prefer incompatibility in case 1 and compatibility in case 2. That is, if they include in their considerations the feedback effect of sales in market A on sales in market B, then they will switch from preferring incompatibility to compatibility. This confirms propositions 1a and 1b: the presence of a multimarket firm tips the market from preferring incompatibility to compatibility.

Secondly, consider the compatibility bonus in case 1, where markets A and B are separately supplied, and the compatibility bonus in case 2, where A and B are jointly supplied. Figure 2.1 looks at the difference between the latter and the former: the gain in compatibility bonus due to market B. Figure 2.1 tells us that market B increases the compatibility bonus, at least for all parameter values considered. Both the parameter β and v_1 tend to increase this profitability bonus.

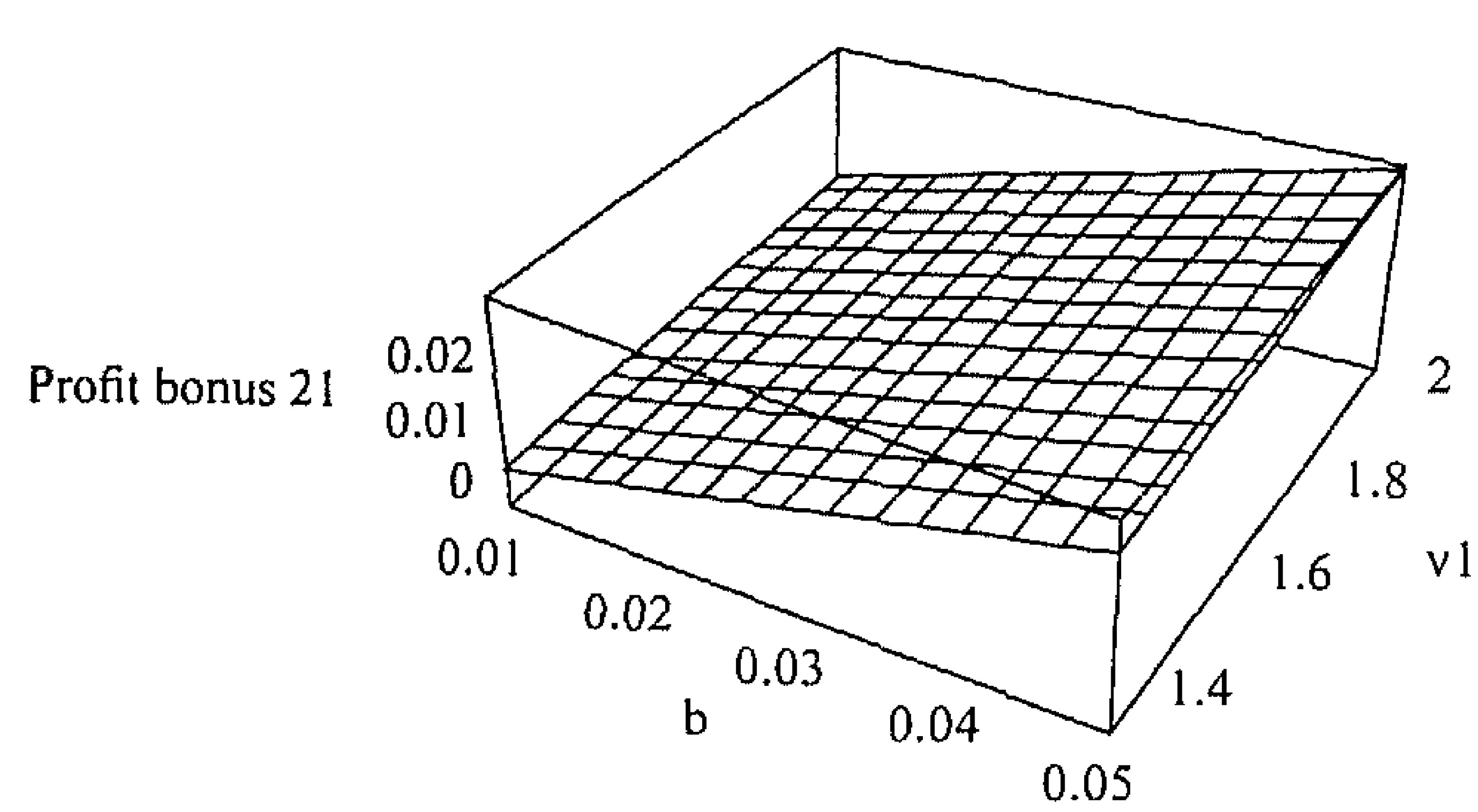

Figure 2.1 Gain in compatibilità bonus

How does the size of profitability in market B, the parameter *d*, influence the profitability bonus? If we define the difference between the compatibility bonus in case 2 and the one in case 1 as a function, we can compute the first derivative of this function to *d*. If we simulate the size of the first derivative, evaluated at the same parameters as before, including that d = 0.2, then the next figure shows the result. Figure 2 shows that the derivative of the differential compatibility bonus to *d* is positive for the parameter values simulated. A higher parameter β and v_1 tend to increase this effect of *d* on the profitability bonus.

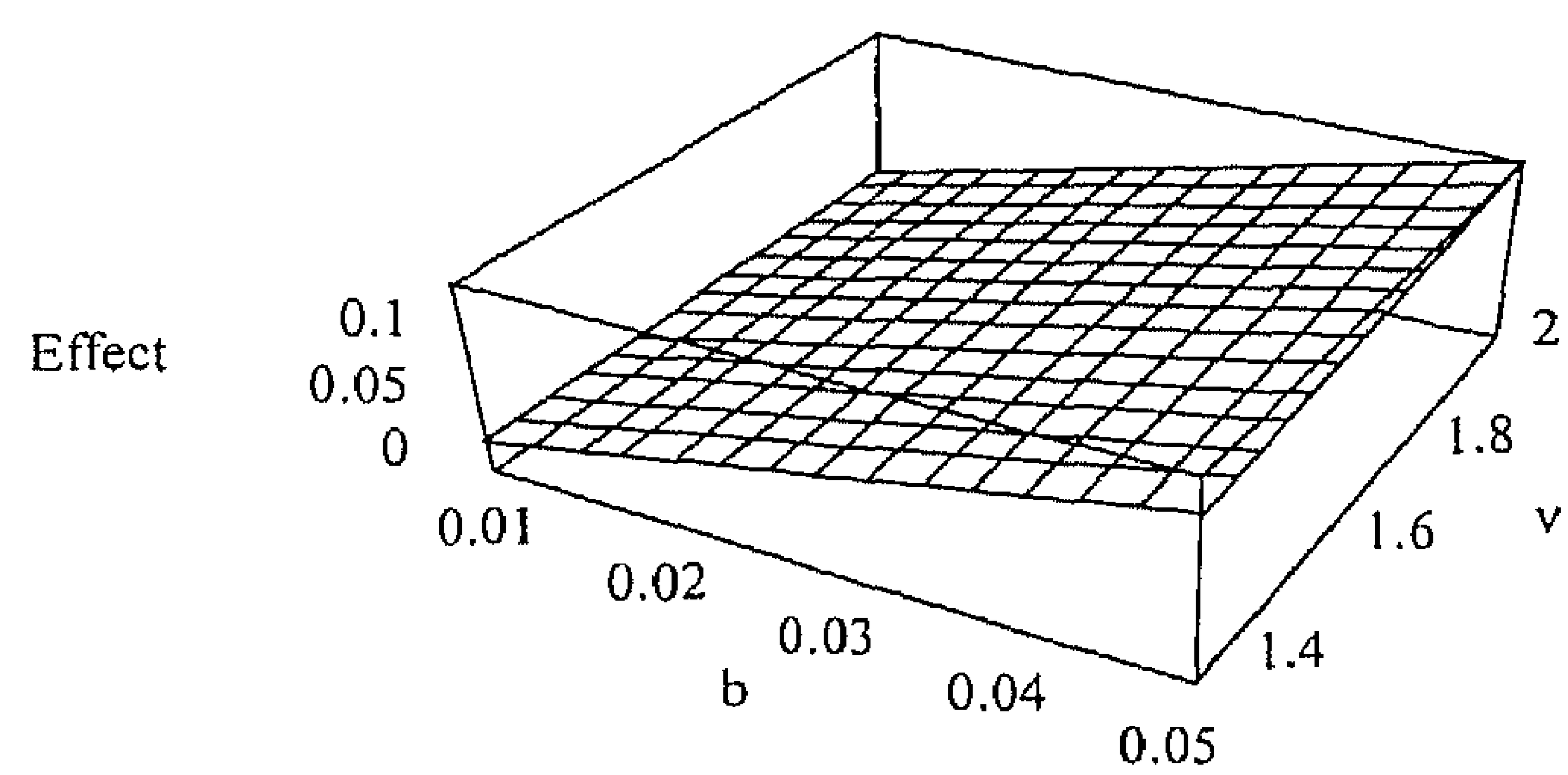

Figure 2.2 Effect of market B profitability on the profitability bonus

Figure 2.3 offers a different view on the compatibility bonus. It reports the profits of firm 2 only. The upper curve is firm 2's profit compatibility bonus from case 2, where it is a multimarket firm, active in both markets A and B. The lower curve is firm 2's compatibility bonus in case 1 where it only serves market A. In both cases its compatibility bonus is positive. Since firm 2 is the low-quality firm, it always benefits from compatibility (at least for the simulated parameter values). The higher v_1 is (on the x-axis), the smaller the market share of firm 2 in market A, all else remaining equal. It benefits more from compatibility when it is a multimarket firm than when it is single-market supplier. The difference of these compatibility bonuses increases when v_1 increases, that is, when its market share in market A decreases. The multimarket firm gains from an increasing v_1, as a higher v_1 increases total demand in A and thus in market B, while the single-market firm is hurt by an increase of v_1, which decreases its market share in market A.

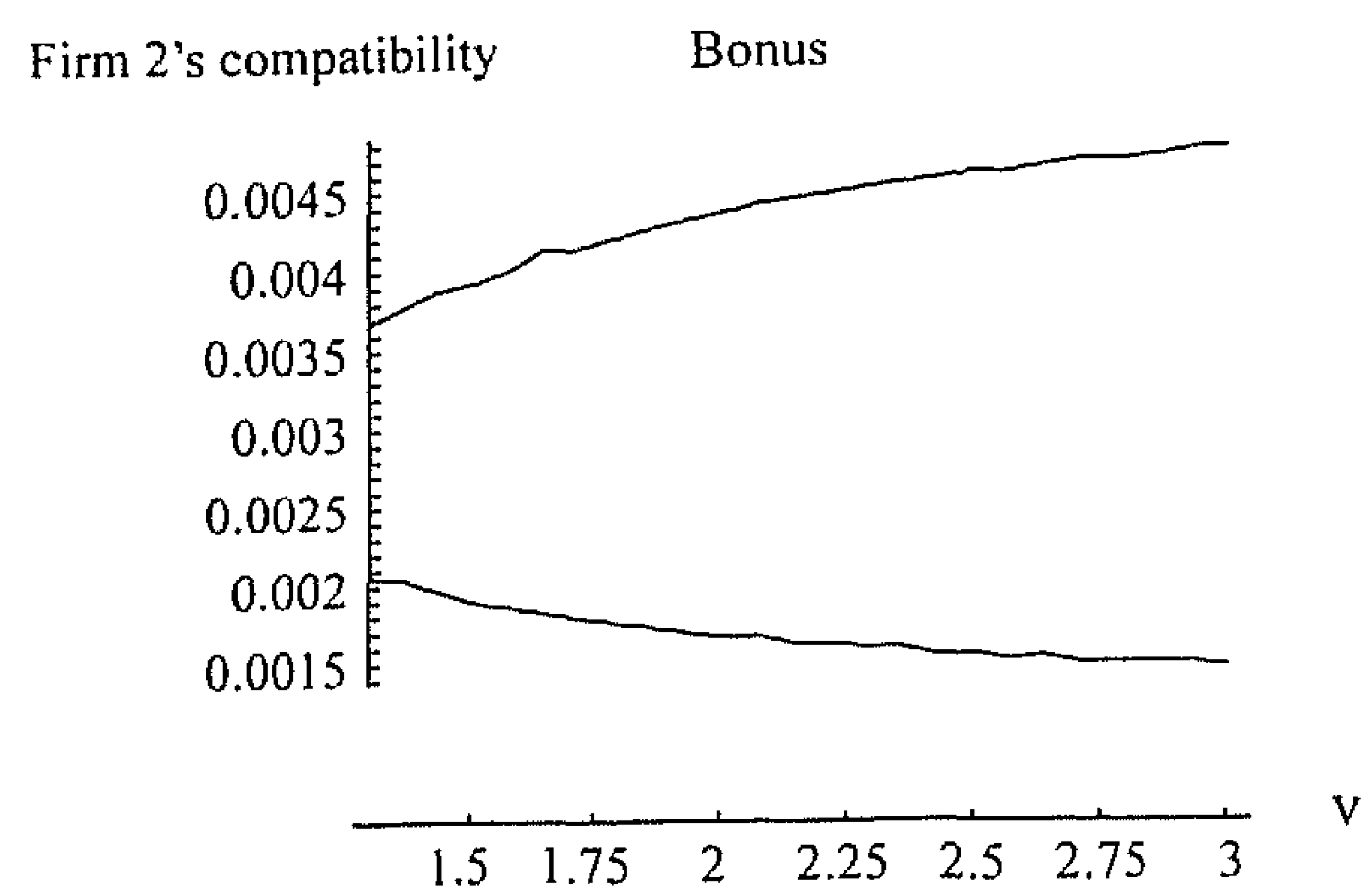

Figure 2.3 Profit compatibility bonus of a multimarket firm

A Case in Point

An Internet technology may illustrate our model. Our main sources is the web journal *C:Net*. The Wireless Application Protocol, or WAP, will enable digital mobile telephones to download and display websites, provided that the telephone has a WAP-enabled browser, and a server has a WAP enabled website. WAP technology fits in the three tier approach:

technology providers →	network providers →	service providers
(handsets and servers)	(GSM operators)	(WAP sites)

The WAP forum maintains and supports the standard. Its pioneering members include Ericsson, Nokia and Intel. 3Com, makers of the popular PalmPilot handheld computer, developed an alternative technology for mobile Internet access, WebClipping. The WebClipping approach uses a mobile telephone as modem and a Palm handheld to display the on-line information. In August 1999, 3Com adopted the WAP for its Palm handheld. Nokia and Ericsson sell handsets and mobile telephone equipment. These markets are expected to benefit hugely from WAP technology, as it will bring e-commerce to mobile telephones, thus increasing the utility of mobile telephony to users. To support their equipment markets, they can give away WAP technology for free. 3Com, instead, makes money from selling handheld computers and, increasingly, licensing its software to competing sellers of handheld computers (such as Acer, Handspring, IBM and Sony). It tried to keep its WebClipping technology proprietary in order to be able to license it and optimize the usefulness of its Palm technology. This may explain its reluctance to participate in the WAP forum. The growing support for the WAP forced it, however, to adopt this technology.

3 Appraisal

This chapter has shown that if firms expand their product scope to become multimarket firms, this changes their preferences for (in)compatibility of products in any particular product market. In the specific case explored here, the multimarket firm has a greater preference for compatibility. The scope enhancing mergers that we observe in Information and Communication Technologies and e-commerce may thus increase the firms' willingness to participate in industry-wide standard setting processes. This indicates a willing view on these mergers. Since multimarket firms have different preferences with regard to standards than do single-market firms, firms may merge in our model, in order to change their preferences. Once mergers give rise to multimarket firms, these may form alliances with the remaining pure players to establish compatible technologies. In our model, at least, mergers and alliances can be complementary rather than substitutes.

To arrive at this result we made some simplifying assumptions that later work may relax. We did away with bargaining processes by invoking the Coase theorem (Milgrom and Roberts, 1992) that firms bargain to an efficient (for them) outcome. We also focused on the product market effects of compatibility choices, while ignoring the effects on technology development processes. More elaborate multimarket spillovers may also be a meaningful area for further research.

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